

INDOOR AIR QUALITY ASSESSMENT

**Brockton City Hall
45 School Street
Brockton, Massachusetts**



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of the Brockton Health Department and State Senator Robert Credon, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at Brockton City Hall (BCH), 45 School Street, Brockton, Massachusetts. On May 1, 2002, a visit was made to this building by Michael Feeney, Director of the Emergency Response/Indoor Air Quality program (ER/IAQ), BEHA to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Suzan Donahue, BEHA Research Assistant, and Doreen Quaglia of the Brockton Health Department. Mr. Feeney returned on May 22, 2002 to complete this assessment. An accumulation of water on the floor of the Health Department office, as well as general indoor air quality concerns, prompted the request.

The BCH is a three-story building with a finished basement constructed around 1900. An attic and subbasement exist in the building. The exterior stone wall was re-pointed in 2000. Windows are openable and consist of double-paned glass in metal window frames. An elevator shaft connecting the second, first and basement levels exist near the center of the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, model 8551. Water content of wood and carpeting was measured with Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

The BCH has an employee population of approximately 80 and is visited by over a hundred members of the public daily. Tests were taken under normal operating conditions and results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million parts of air (ppm) in five of forty-three areas sampled, indicating adequate air exchange in most areas of the building. Offices throughout city hall do not have mechanical fresh air supply, with the exception of offices in the engineering department and the City Council chambers. Each of these areas is serviced by roof top air handling units (AHU) (see Picture 1), which were deactivated during the assessment. The sole source of fresh air into most areas of the building is via openable windows.

Each room with windows is equipped with a fan coil unit (FCU) (see Picture 2). Each FCU is located on exterior walls underneath windows. The purpose of the FCU is to provide heating or cooling by circulating air. The FCUs are incapable of introducing fresh outdoor air. The FCU draws air from the room through a filter in the base of the cabinet into fans. Fans force air through coils that heat or chill the air. Conditioned air exits the FCU through fixed louvers on the top of the cabinet. FCUs were not operating in most offices evaluated. Some FCU are blocked with office furniture and other items, which can hinder the operation of this equipment.

Each office area appears to have an exhaust ventilation system (see Picture 3). The exhaust grilles appeared to be connected to an exhaust fan located in the attic. The attic exhaust vent was disconnected from its original roof terminus and its motor was removed. The fan housing stands open in the attic and now serves as a pathway for attic air to migrate into offices. Further, without mechanical exhaust ventilation normally occurring environmental pollutants may accumulate in offices. In this configuration, the BCH does not have an operational ventilation system that could introduce fresh air or provide exhaust ventilation.

A number of areas are not connected to the exhaust ventilation system. Openable windows provide ventilation in areas equipped with them. During summer months, ventilation in the BCH was originally controlled by the use of openable windows. The BCH was configured in a manner to use cross-ventilation to provide comfort for building occupants. The building is equipped with windows on opposing exterior walls. In addition, the building has hinged windows located above the hallway doors. This hinged window (called a transom) (see Picture 4) enables building occupants to close the hallway door while maintaining a pathway for airflow. This design allows for airflow to enter an open window, pass through an office and subsequently pass through the open transom. Airflow then enters the hallway, passing through the opposing open office transom, into the opposing room and finally exits the building on the leeward side (opposite the windward side) (see Figure 1). With all windows and transoms open, airflow can be maintained in a building regardless of the direction of the wind. The system fails if the windows or transoms are closed (see Figure 2). Transoms are opened using a rod to open a latch on each window frame. Most transoms are inoperable.

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please refer to [Appendix I](#) of this report.

Temperature readings were measured in a range of 72° F to 79° F, which are very close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Concerns about lack of control over heat in office spaces during winter months and complaints of excessive heat during summer months were expressed to BEHA staff.

The window system has double-paned glass, which are energy efficient windows. Without a mechanical ventilation system, the installation of energy efficient windows can lead to increased discomfort from heat accumulation in offices, particularly on the south side of the building. Adding to the heat load within the building is the introduction of computers, LaserJet® printers, photocopiers, refrigerators and facsimile machines in the building. Each piece of equipment produces waste heat. Since the building was built around 1900, it was not designed to handle modern office equipment; the combination of a lack of exhaust ventilation with equipment that produces waste heat and double-paned, metal-framed window systems can make temperature control difficult. Temperature readings outside the recommended comfort range are generally not a health concern, however they can affect the relative humidity in a building.

The original heating system consists of a boiler system connected to the FCUs by steel piping. Some offices have uninsulated steel pipes that are connected to FCUs. The temperature of these pipes was measured in a range of 227° F to 232° F. These exposed

pipes produce a large amount of uncontrolled heat, which should be regulated by the FCUs.

The relative humidity in the BCH was below the BEHA recommended comfort range of 40 to 60 percent in all areas surveyed. Relative humidity measurements ranged from 24 to 35 percent. The sensation of dryness and irritation is common in a low relative humidity environment. For buildings in New England, periods of low relative humidity during the winter are often unavoidable.

Microbial/Moisture Concerns

Concerns about moisture accumulation in the Brockton Health Department office (BHDO) were the primary focus of this assessment. Office occupants reported musty odors in this area. An accumulation of moisture was noted underneath file cabinets near a door threshold that leads to the back offices (see Picture 5). Moisture samples were taken in carpet and wood in and around the floor. Wood of the doorframe and coving had normal moisture readings (< 15%). Wood of the threshold had a moisture content greater than the other wood sampled (>15% water concentration), indicating it may be moistened by a water source within the building. The threshold was removed, which released a strong musty odor near the floor.

A number of theories exist as to the source of the denoted moisture:

1. Water from a plumbing leak from a pipe beneath the elevated floor;
2. Water penetration through the exterior wall;
3. Leaking from the sink;
4. Water penetration through the walls above the health department office; or
5. Water leakage from the exhaust vent system.

Each of these theories does not appear to be the source creating the moistening of the timber of the false floor. An examination of the subbasement area below the BHDO found the floor of the catacomb area dry. The area was also free of dripping water which, if water is leaking in the floor above this area, should be present. The slope of the ground, re-pointing of brickwork and height of the floor all appear to eliminate outdoor water penetration as a source of floor moistening. No leaking pipes or wet spots underneath the sink could be identified. No water-damaged plaster or saturated wood was found above the floor threshold. Since the original exhaust system was disconnected from the roof, no pathway exists for rainwater to penetrate into the BHDO. All of these possible pathways for moisture do not appear to exist in or around the BHDO. Therefore, the moisture source most likely causing mold growth is water vapor condensing on cold surfaces below the false floor.

The floor in the basement is made of stone and tiles in offices (see Pictures 6 and 7). An elevated floor was installed in basement offices on top of the stone/tile floor. This installation created a cavity, through which uninsulated pipes for the heating system exist. This configuration creates conditions in the floor space to generate condensation.

Condensation is the collection of moisture on a surface that has a temperature that is below the dew point. The dew point is a temperature that is determined by air temperature and relative humidity. As an example, at a temperature of 76° F and relative humidity of 30%, the dew point for water to collect on a surface is approximately 43° F. Air temperature measured around uninsulated heating pipe(s) (see Picture 7A) that enter the floor beneath the BHDO was 153° F. All available psychrometric charts examined by BEHA staff list a maximum air temperature of 115° F (IICRC, 1999). If the relative

humidity is 30%, the dew point for generation of condensation is approximately 76 ° F (at 115 ° F air temperature). Therefore, any surface that has a temperature below 76 ° F (e.g., the floor below the BHDO carpeting/false floor cavity) would be prone to condensation generation. The temperature of the health department stone floor was measured at 53 ° F beneath the sink and 61 ° F at the threshold. The carpet in this office had a surface temperature of 63 ° F. All of these temperatures are over 60 ° F below the dew point of 76 ° F (assuming 115 ° F air temperature, 30% relative humidity). This temperature disparity would not be expected to *increase* as temperature increases beneath the floor. Therefore, condensation generation beneath the floor appears to be the most likely source of moisture creating the accumulation. As reported by Ms. Quaglia, other offices experience water accumulation near the floor threshold. Each of these offices with uninsulated heating pipes would also be subject to chronic wetting like the BHDO.

Once water accumulates, this condition can result in chronic moistening of wood used to construct the false floor. Conditions that result in chronic moistening of wood over time can produce fungal growth, particularly within a space that does not have air movement, such as the floor cavity.

As discussed, the BHDO is not the only basement office that experiences water pooling. The tax office experiences water accumulation near a hallway door in close proximity to an uninsulated heating pipe (see Pictures 7B and 7C). Occupants in the assessor's main office report wood rot to the point where the floor was removed. No signs of water damage appeared in carpeting or other materials in the assessor's office. Occupants report that no further signs of water generation exist in this area since the removal of the false floor.

Two sources of water vapor exist in the building: occupants and outdoor air penetration from the boiler room. As individuals exhale, a number of products of respiration are added to the indoor environment, including water vapor. In an environment without a mechanical ventilation system, occupant produced water vapor cannot escape from the building. Compounding these problems was the exterior brick re-pointing project, which resulted in the reduction of air infiltration or moisture exfiltration from the basement offices. BHDO personnel report that they perceive that water pooling at the threshold had *increased* since the repair of exterior walls, which would be consistent with sealing means for moisture to escape the BCH. The second source of moisture appears to be the boiler room combustion air vents. These vents are located on the south side of the building (see Picture 8). Moist weather tends to travel in a northeasterly track up the Atlantic Coast towards New England (Trewartha, G.T., 1943). Wet weather systems generally produce south/ southwesterly winds, which can enter into the boiler room via the combustion air vent (see Figure 3). With wind penetrating through the combustion air vents, the boiler room becomes pressurized, which then can force air into the catacombs and subsequently force air through spaces in the floor of basement offices. Several facts confirm that a pathway exists for air to move from the boiler room to basement offices.

1. Several incidents were reported by building occupants of oil and solvent odors penetrating into the BHDO from the boiler room during use.
2. BEHA staff detected of musty odors in the boiler room and similar odors in the BHDO around a pipe (see Picture 9) that penetrates into the catacomb.

3. BEHA staff identified that same musty odor emanating from a sink cabinet in the tax office.
4. A door separating the boiler room from the catacombs was removed, presumably for installation of electrical conduit (see Picture 10). This door may have reduced the pressurization of the catacombs. Once the door was removed, boiler room air could freely move into the catacombs and then into basement offices through the floor.
5. The door to the boiler room is not airtight nor is it fire-rated. Space around the boiler room door can allow boiler room odors to penetrate into the basement area.

If a moist weather system pressurizes the boiler room, moist air can then be forced into the catacombs, which can then enhance condensation beneath the false floors.

Conditions also exist in the basement that may result in chronic moistening of carpet. Carpeting installed on top of chronically moistened flooring materials may also become moistened as a result of water wicking up in spaces in floor materials. In addition, water coolers located on wall-to-wall carpeting were noted in offices. Use of the water cooler can result in chronic moistening of carpeting. Water damaged carpeting can serve as mold growth media. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

The configuration of drainage as well as the condition of the interior of FCUs may also be a source of microbial growth. Each FCU has the capacity to provide heat and air-conditioning. As FCUs operate in the air conditioning mode, condensation accumulates on the coils as air is chilled. Each FCU has drip pans to collect and drain condensation from cooling coils (see Picture 11). Several units were examined and were found to have drip pans coated with dirt and other debris, which can serve as growth mediums for mold when these units are activated for air conditioning. Several employees indicated that mold odor emanates from the FCUs when activated. The drip pan collectors (see Picture 12) are also coated with dirt and debris, suggesting that these units are not routinely cleaned. In an effort to control microbial growth, a packet of alkaline materials was placed in the drip pan.

FCUs in basement offices empty into a pump (see Picture 13). The pump is connected by plastic hose to a vertical, metallic pipe [which appears to be reused electrical conduit (see Picture 14)], which is in turn, connected by plastic hose to an existing drain system over ten feet above the FCU. It could not be determined whether the pumps have sufficient horsepower to pump collected condensation from the collectors. This may result in water overflow from the condensation pumps, which can then moisten carpet (see Picture 15).

Mold growth was evident on pipe insulation on heating pipes near the ceiling of the mailroom (see Pictures 16). The condition of these pipes may indicate that either insulation has spaces that allow for air to come in contact with the bare pipe or that the insulation does not have a sufficient R rating.

There appear to be several sources of moisture resulting in condensation. Condensation occurs if spaces in the insulation exist or the R rating of the insulation is not sufficient. Spaces between insulation sections can allow for moist air to come in contact with the metal of the chilled water pipes, which creates condensation. The R rating is a mathematical representation of the ability of insulation to prevent temperature transfer. If an air conditioning system has chilled water pipes with an insufficient R rating, temperature could be transferred to the surface paper, thus creating condensation. Once water wets insulation, a temperature bridge is created, which results in further wetting of insulation and enhancing mold growth. In order to cease the continued production of moisture on these pipes, the air conditioning system supplying the chilled water must be deactivated. While the chiller deactivation will prevent the further production of condensation, the reactivation of the chilled water system without taking steps to replace dampened pipe insulation would be expected to result in further water damage and potential mold growth.

Other Concerns

Several additional conditions were noted during the assessment, which can effect indoor air quality. The interiors of a number of FCU were examined. An antimicrobial agent (Pan Pad[®] Condensate Treatment) was found in every drip pan examined (see Picture 17). The product sheets for this material indicate it is to be used as a broad-spectrum antibiotic that also is effective against *Legionella pneumophila* (Nu-Calgon, 2002a). The use of this product in FCU drip pans is unnecessary. In order to support bacteria growth such as *L. pneumophila*, moisture within a temperature range must be

achieved. The ideal temperature for this microorganism to grow is at temperatures between 80 to 120° F (27 to 49° C) in the presence of sunlight, oxygen, and nutrients such as phosphorous, nitrogen, sulfate and carbon dioxide (Lane, R.W., 1993). Organisms such as algae, mold, *Legionella pneumophila* (Gold, D. 1992) and other microbes have been found to grow within HVAC equipment that reuse water, such as cooling towers. The purpose of cooling towers in an HVAC system is to **remove heat from coolant**, which warms water to the requisite temperature for microbial growth. The purpose of drip pans is to **drain** moisture generated by *cooling coils*. The temperature of FCU coils in the cooling mode during the summer is less than 60° F. Lower temperature and removal of moisture through proper drainage would limit microbial growth in FCUs, rendering the use of the Pan Pad® product unnecessary.

Of note are the constituents of the Pan Pad® product. This product consists of two organic ammonium chloride compounds and borax (disodium tetraborate) (Nu-Calgon, 2002a), all of which are alkaline materials. BEHA staff removed a Pan Pad® from a FCU. The odor produced by this product is characterized as a “mothball-like” odor. As condensation contacts the Pan Pad® surface, a 14% solution of Pan Pad® ingredients is formed in water (Nu-Calgon, 2002b). This solution may become aerosolized during FCU operation if standing water exists in drip pans. This solution may also contaminate carpeting as water overflows from condensation pumps. Exposure to this product may cause irritation to the eyes and skin. BEHA staff has contacted Nu-Calgon to ascertain if this product is being used in conformance with manufacturer’s instructions.

The original exhaust system fan was located in the attic (see Picture 18 and 18A). It appears that this fan was disconnected from the roof when the AHU that services the

interior offices of the engineering department was installed. This system was not abandoned. The original fan duct is open to the attic and all exhaust vents remain open in offices throughout BCH. This pathway may allow for pollutants in the attic to migrate to offices. Some restroom vents are vented into the attic (see Picture 19), which then may migrate to offices via the abandoned exhaust ventilation system.

The basement condensation pumps are connected to a drain system that exists along the ceiling of basement offices. BEHA staff traced this pipe to the boiler room, where it is buried beneath concrete. It could not be determined whether this pipe system has a drain trap. The purpose of a drain trap is to prevent odors from the sewer system from backing up into a building's interior. Without a trap, sewer gas may periodically backup and enter the building from the condensation drain system. Sewer gas can be irritating to the eyes, nose and throat.

The City Clerk's office contains a fireplace that is no longer in use (see Picture 20). The flue for the chimney is not sealed, which may allow for air to penetrate into this office. The chimney for the fireplace exists on the roof. The top of the chimney is open, which can allow rainwater to penetrate down the shaft. In addition, animals/pests may also enter the building through the chimney.

Spaces exist in the FCU cabinet walls that can allow for unfiltered air to bypass filters. Open pipes and spaces around pipes can serve as pathways for dust, dirt, odors and other pollutants to move from the floor/wall cavities into occupied areas during operation of FCUs.

Many offices contain photocopiers. Photocopiers can produce volatile organic compounds (VOCs) and ozone, particularly if the equipment is older and in frequent use.

Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). No mechanical exhaust ventilation is provided in these areas. Without mechanical exhaust ventilation, excess heat, odors and pollutants produced by office equipment can build up and lead to indoor air quality complaints.

Periodic rodent sightings were also reported to BEHA staff. An open container of rat poison was found beneath the radiator in the public health nurse's office (see Picture 21). Rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine contains a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms readily in sensitive individuals. A three-step approach is necessary to eliminate rodent infestation:

1. removal of the rodents;
2. cleaning of waste products from the interior of the building; and
3. reduction/elimination of pathways/food sources that are attracting rodents.

To eliminate exposure to allergens, rodents must be removed from the building. Please note that removal, even after cleaning, may not provide immediate relief since allergens can exist in the interior for several months after rodents are eliminated (Burge, H.A., 1995). A combination of cleaning, with an increase in ventilation and filtration should serve to reduce rodent associated allergens once the infestation is eliminated.

A hole was noted in the attic for pipes connected to the turret-top chiller unit. While no pests were found inside the attic, these holes can serve as a means of egress for birds, bats, insects and other pests. Each of these holes should be sealed to prevent pest infiltration.

Conclusions/Recommendations

The conditions observed in the BCH are somewhat complex. The combination of no functional fresh air and exhaust ventilation systems with water damage to the floor in the BHDO, uncontrolled air penetration from the boiler room, the potential for aerosolizing alkaline materials and other environmental problems provide conditions that can degrade indoor air quality. Removal of the false floor for all basement offices effectively warrants serious consideration in terms of remediating the building. Ventilation alone cannot serve to reduce or eliminate mold growth in these materials. The false floor should not be removed while offices are occupied, since it is likely that renovations may disturb asbestos-containing tiles that may exist on the true floor. Care should be given to prevention of exposure to BCH occupants to renovation-generated pollutants.

Please see the **Renovations** section of this assessment for recommendations for prevention of migration of renovation-generated pollutants into occupied areas. In order to address the conditions listed in this assessment, the recommendations made to improve indoor air quality are divided into **short-term** and **long-term** corrective measures. The **short-term** recommendations can be implemented as soon as possible. **Long-term** solution measures are more complex and will require planning and resources to adequately address overall indoor air quality concerns. In view of the findings at the time of the visit, the following recommendations are made:

Short Term Recommendations

1. Remove the false floor in all basement offices.
2. The building was designed to use windows to provide fresh air. Since no mechanical ventilation is available, the opening of windows is recommended to temper room temperature and provide fresh air during the **heating season only**. Opening windows during hot weather during summer months will introduce moisture into the building, resulting in condensation generation on chilled water pipes during operation of the chiller.
3. Deactivate the air-conditioning system until control of condensation from the AC system is achieved. Consult with a ventilation engineer concerning appropriate measures to control condensation generated by the air-conditioning system.
4. Use transoms to enhance airflow during warm weather. Be sure to close transoms at the end of the business day. To aid in the draw of fresh outdoor air in warm weather, use portable fans directing air out windows on the leeward side (opposite the windward side) of the building. Fans positioned in this manner will serve to increase the draw of outdoor air across a floor without interfering with the natural internal airflow pattern of the building. To aid cross ventilation, open hallway doors.
5. Remove Pan Pads[®] from all FCU drip pans.
6. Clean accumulated debris from FCU drip pans and condensation collectors.
7. Consider reconfiguring office space to prevent blockage of FCUs.
8. Ensure that condensation pumps have sufficient horsepower to pump condensation into the drain system. If not possible, elevate the pump closer to the

drain to decrease the distance of pipe. Replacement of condensation pumps with ones with a larger horsepower capacity may be necessary.

9. Seal holes in the floors, walls and ceilings for pipes and cables to prevent infiltration of pollutants from wall cavities and the catacomb into occupied areas.
10. Reinstall the door separating the boiler room from the catacombs to provide an air baffle to decrease pressurization of catacombs.
11. Examine the feasibility of replacing the boiler room door with a fire rated door in an airtight frame.
12. Seal all plumbing penetrations in the basement floor to prevent odor migration into occupied areas.
13. Place an impermeable material (e.g., rubber or plastic) beneath water coolers to prevent water damage to carpeting.
14. Seal the abandoned exhaust vent fan in the attic.
15. Seal abandoned exhaust vents throughout the building to prevent pollutant migration.
16. Examine the wall behind the pipe extending from the northeast corner of the BHDO for air spaces and seal to prevent boiler room odor migration.
17. Seal unused chimneys on the roof to eliminate water penetration/pest infiltration. For chimneys still in use, consider installing a chimney cap to prevent rainwater penetration.
18. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can

be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

19. Seal hole around chiller pipes in attic to prevent pest infiltration.
20. Install means to vent restroom air outdoors.
21. Examine the drainpipe in the boiler room and determine whether a trap exists. If no trap exists, consult a plumber to consider the best options to prevent sewer gas backup, which may include installation of a drain trap.
22. It is highly recommended that the principles of integrated pest management (IPM) be used to rid this building of pests. A copy of the Massachusetts IPM recommendations are included with this report as [Appendix II](#) (MDFA, 1996). Activities that can be used to eliminate pest infestation may include the following:
 - a) Rinse out recycled food containers. Seal recycled containers with a tight fitting lid to prevent insect/rodent access.
 - b) Remove non-food items that pests may be consuming.
 - c) Store foods in tight fitting containers.
 - d) Avoid eating at work stations. In areas where food is consumed, periodic vacuuming to remove crumbs is recommended.
 - e) Regularly clean crumbs and other food residues from toasters, toaster ovens, microwave ovens, coffee pots and other food preparation equipment.

- f) Examine each room and the exterior walls of the building for means of egress and seal. If doors do not seal at the bottom, install a weather strip as a barrier to pests.
- g) Reduce harborages (cardboard boxes) where pests may reside.

Long Term Recommendations

1. Inspect woodwork in close proximity to sub-flooring for mold growth or water damage. If mold contaminated, remove in accordance with recommendations in the US Environmental Protection Agency's Mold Remediation in Schools and Commercial Buildings guide (US EPA, 2001).
2. Consider restructuring the condensation drains for basement AHU to empty outside the building through window frames.
3. Replace chilled water pipe insulation with a sufficient R rating to prevent generation of condensation on these pipes.
4. Insulate heating pipes to prevent future condensation generation.
5. Install a duct/baffle on the interior of the makeup air vents in the boiler room to reduce/prevent boiler room pressurization.
6. Consideration should be given to providing mechanical fresh air and exhaust ventilation for all offices in BCH. Examine the feasibility of using the abandoned exhaust system as fresh air ductwork. Return air ventilation may be done with ducting or by using the interior hallways as a plenum return system.
7. Consider providing local exhaust ventilation for photocopiers.

Renovations

The following recommendations should be implemented prior to any future renovations to reduce/eliminate the migration of pollutants into occupied areas. We suggest that these steps be taken on any renovation project within a public building:

1. Establish communications between all parties involved with building renovations to prevent potential IAQ problems. Develop a forum for occupants to express concerns about renovations as well as a program to resolve IAQ issues.
2. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
3. When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
4. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.
5. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).
6. Consult MSDS' for any material applied to the effected area during renovation(s). Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.

7. Develop a means to create local exhaust ventilation and use isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the building's ventilation system (SMACNA, 1995).
8. Seal utility holes, spaces in roof decking and temporary walls to eliminate pollutant paths of migration. Seal holes created by missing tiles in ceilings to prevent renovation pollutant migration.
9. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.
10. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a HEPA equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.

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Figure 1

Cross Ventilation in a Building Using Open Windows and Transoms

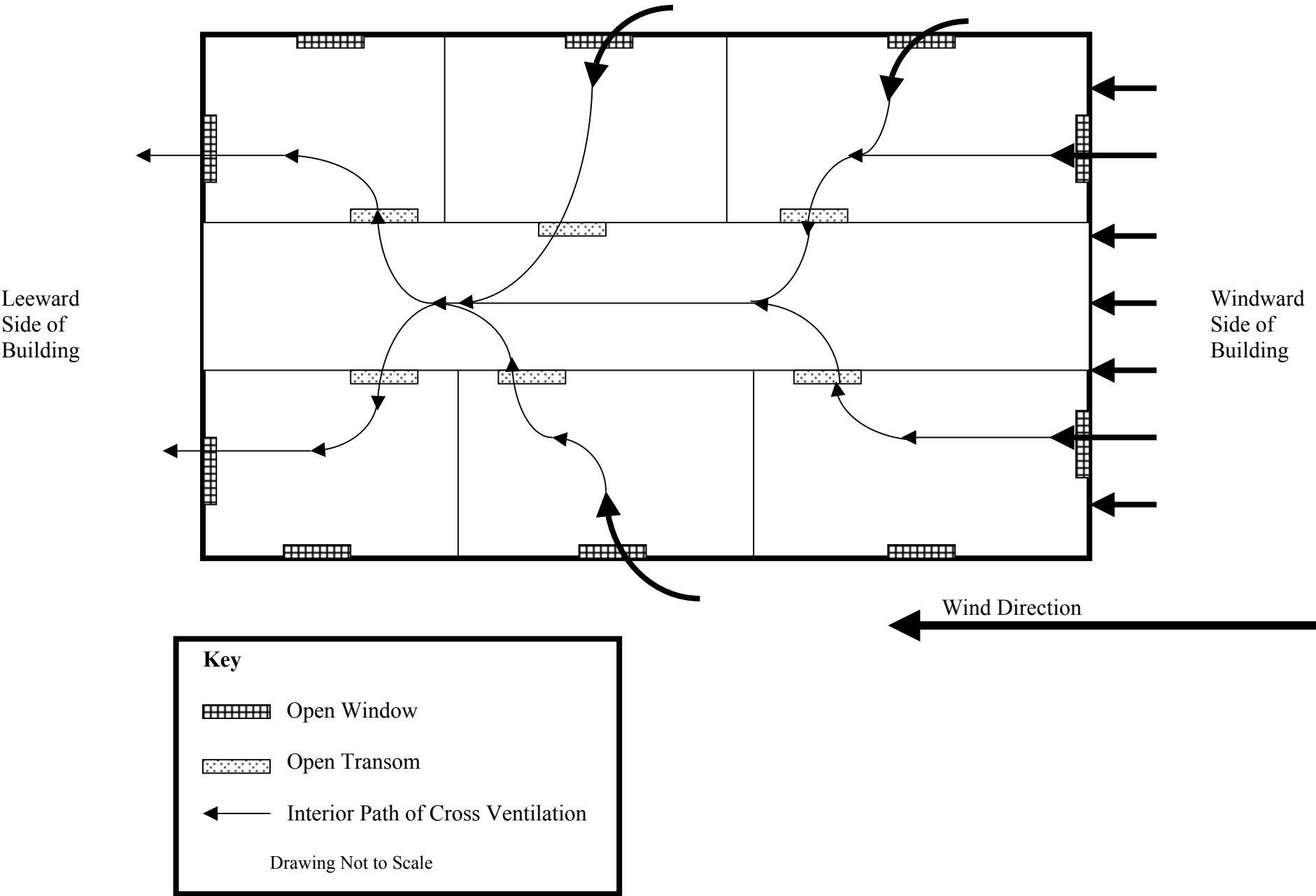


Figure 2

Inhibition of Cross Ventilation in a Building with Several Windows and Transoms Closed

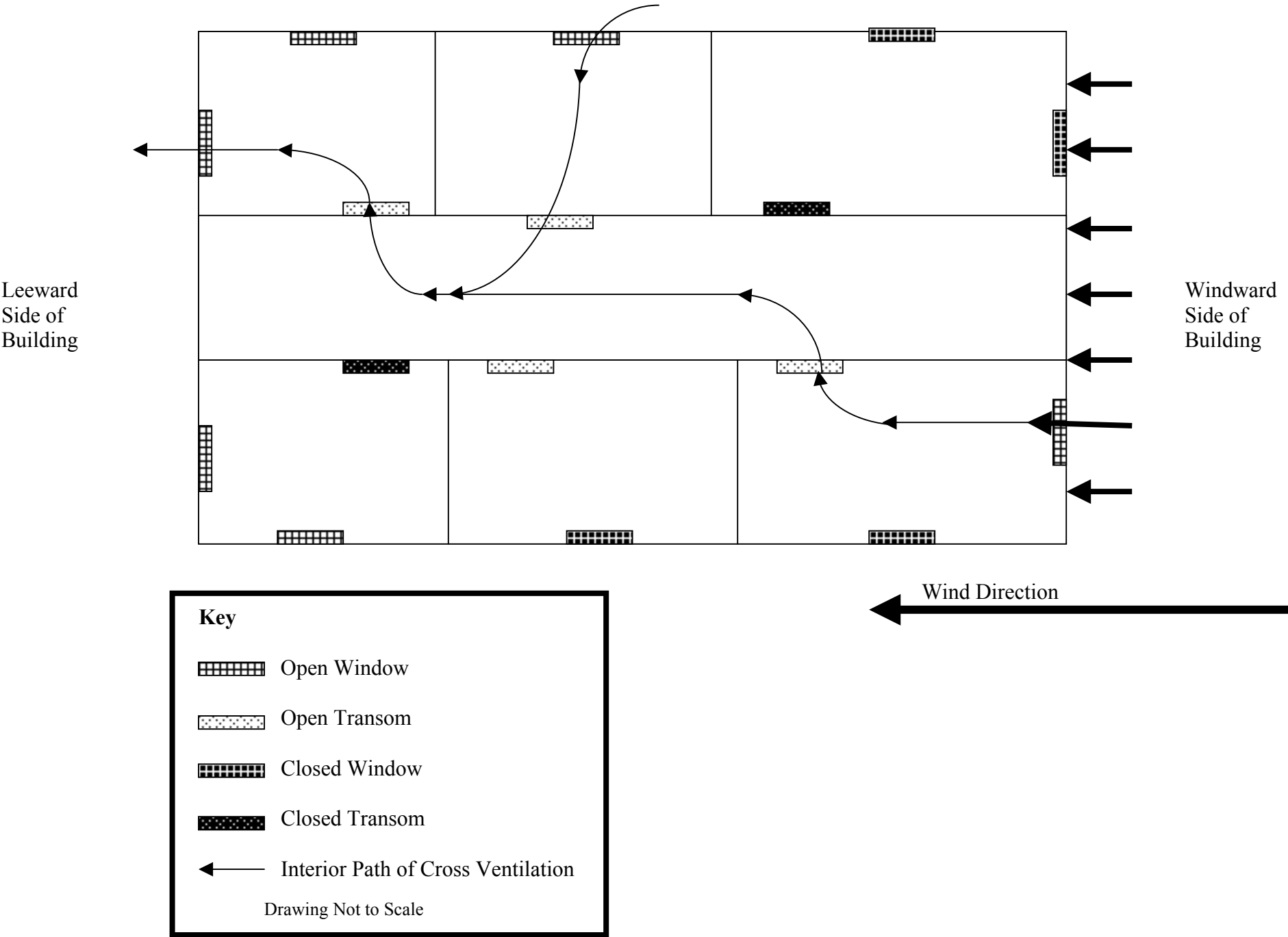
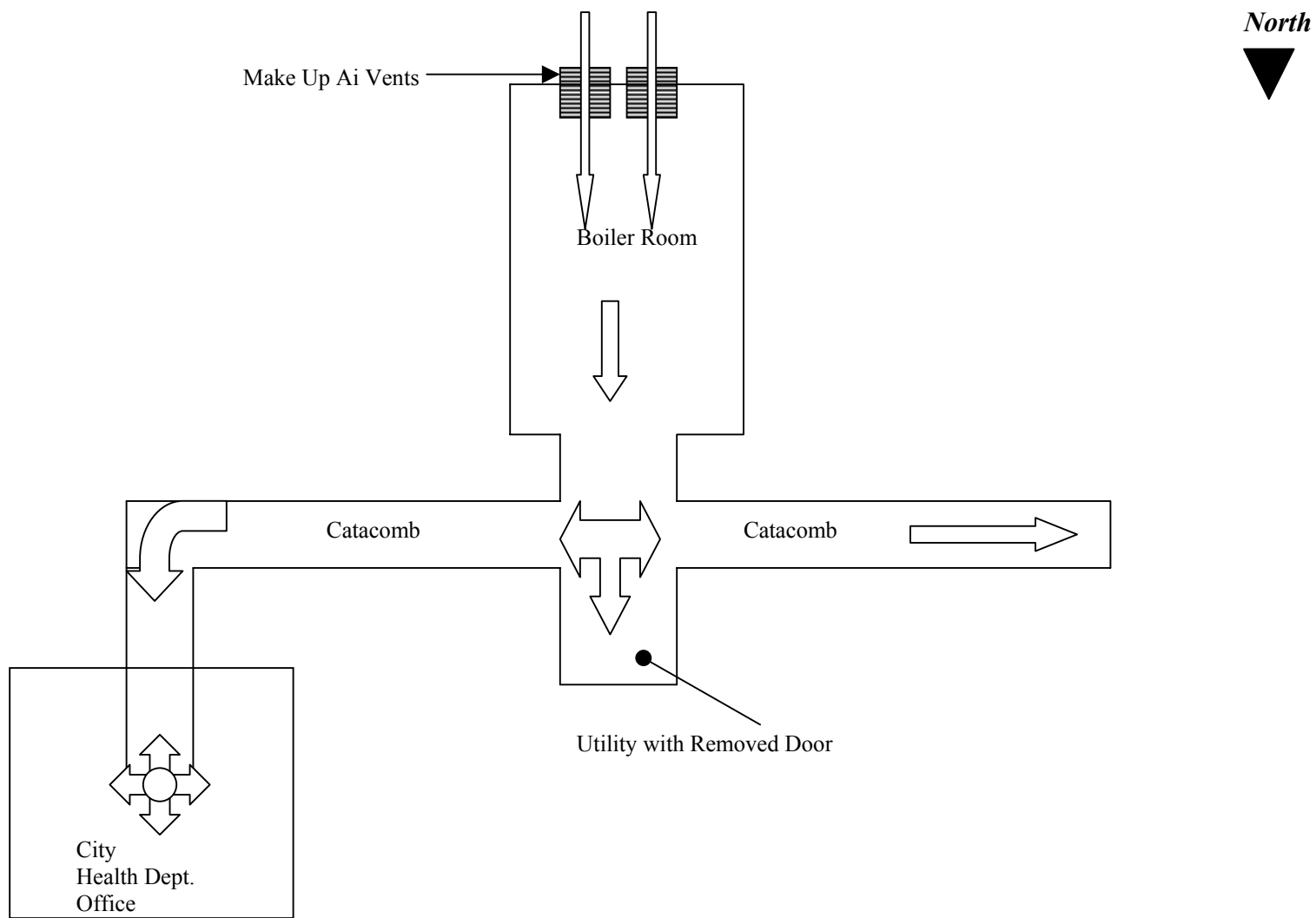
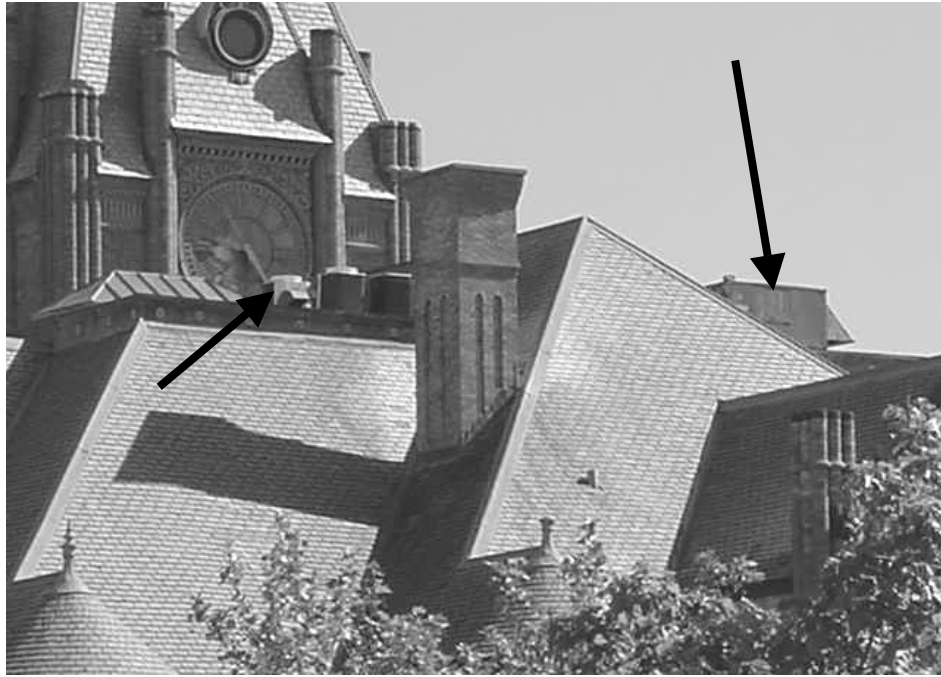


Figure 3
Pressurization Of Boiler Room In South Wind Which Forces Odors Into Basement Level Offices
(Arrows indicate airflow direction)



Picture 1



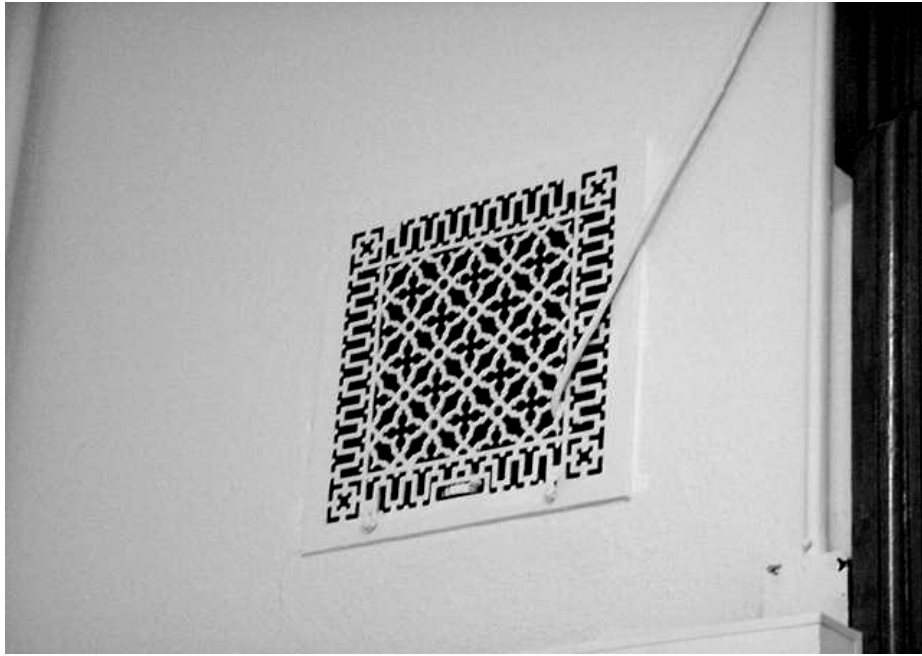
AHUs on Roof of BCH

Picture 2



Typical FCU in BCH Office

Picture 3



Exhaust Vent in Wall

Picture 4



A Transom

Picture 5



Water Accumulation Noted in BHDO

Picture 6



Floor In Basement Hallway

Picture 7



Tile Floor in Mailroom

Picture 7A



Heating Pipe Entering False Floor In BHDO, Note Lack Of Insulation

Picture 7B



Threshold of Tax Office Door (Room 5) that is Prone To Water Accumulation

Picture 7C



Uninsulated Heating Pipe near Door Threshold of Tax Office (Room 5)

Picture 8



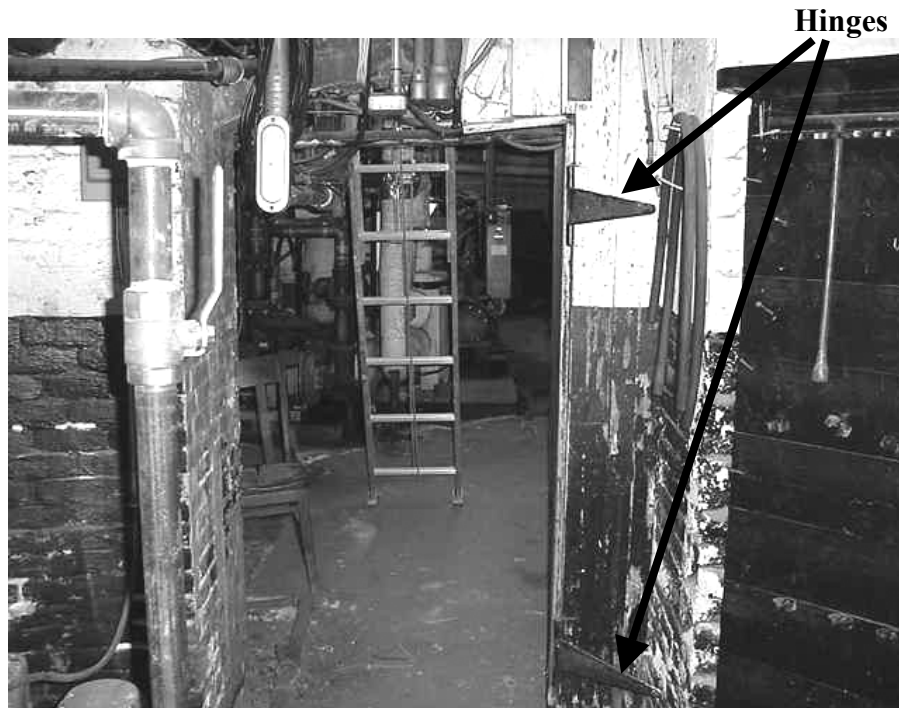
Exterior Of Combustion Air Vents On South Wall of BCH

Picture 9



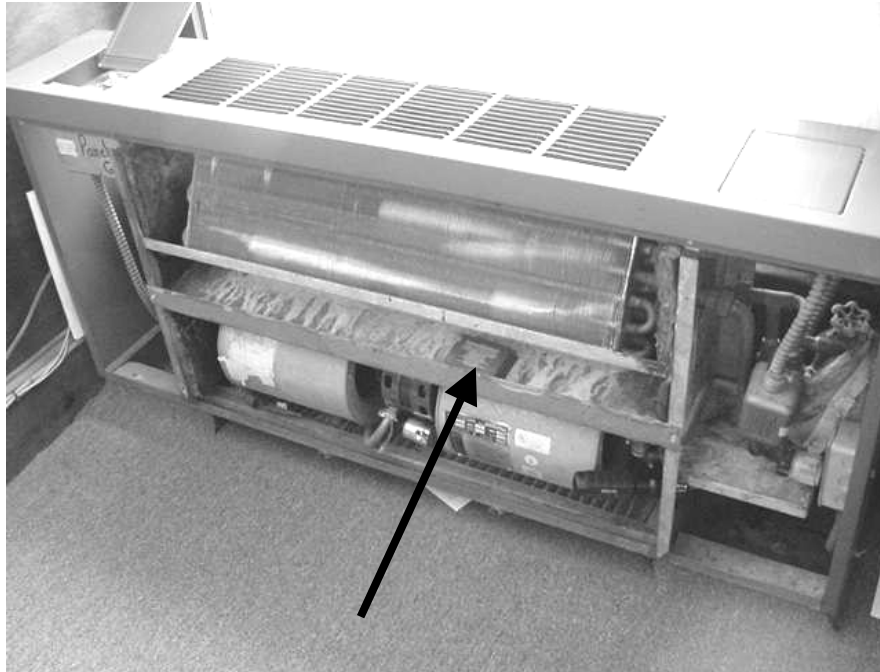
Pipe In BHDO That May Be Odor Pathway From Catacombs

Picture 10



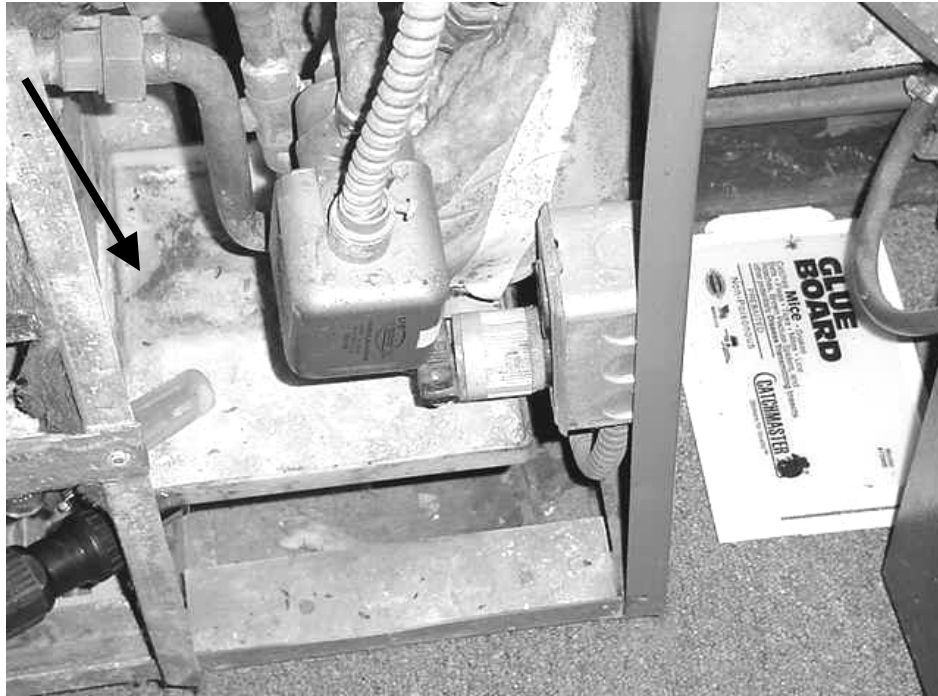
A View from the Catacombs of the Doorway to the Boiler Room, Note the Existence Of Door Hinges, Indicating That A Door Formerly Was Installed Over This Portal

Picture 11



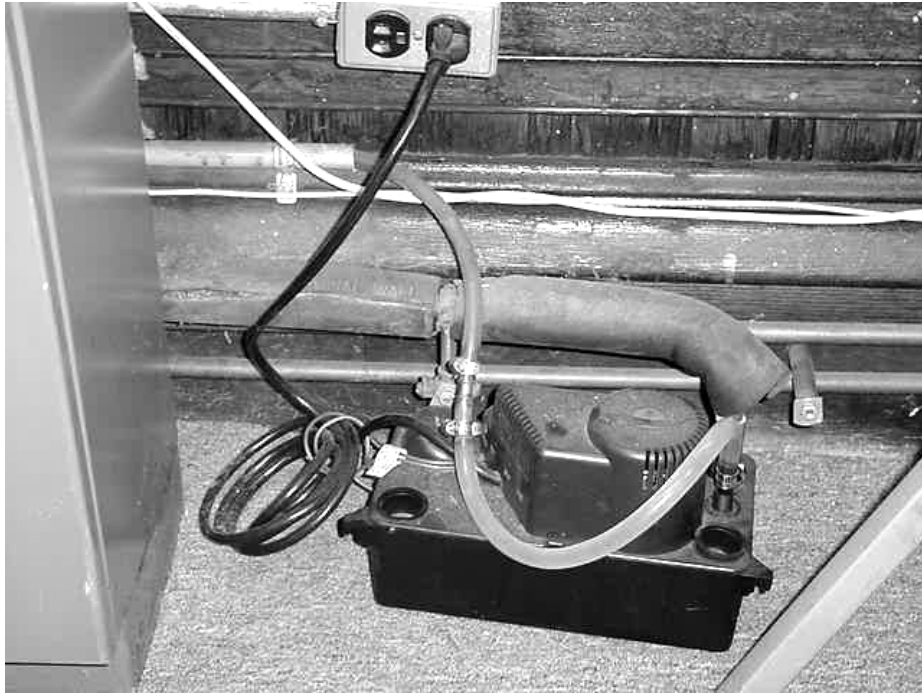
Interior of FCU, Note Drip Pan and Box Inside Drip Pan

Picture 12



Debris in FCU Drip Collector

Picture 13



Condensation Pump For FCU, Note Seams in Insulation and Exposed Metal of Pipes

Picture 14



Metallic Pipe Connected To FCU Condensation Drains

Picture 15



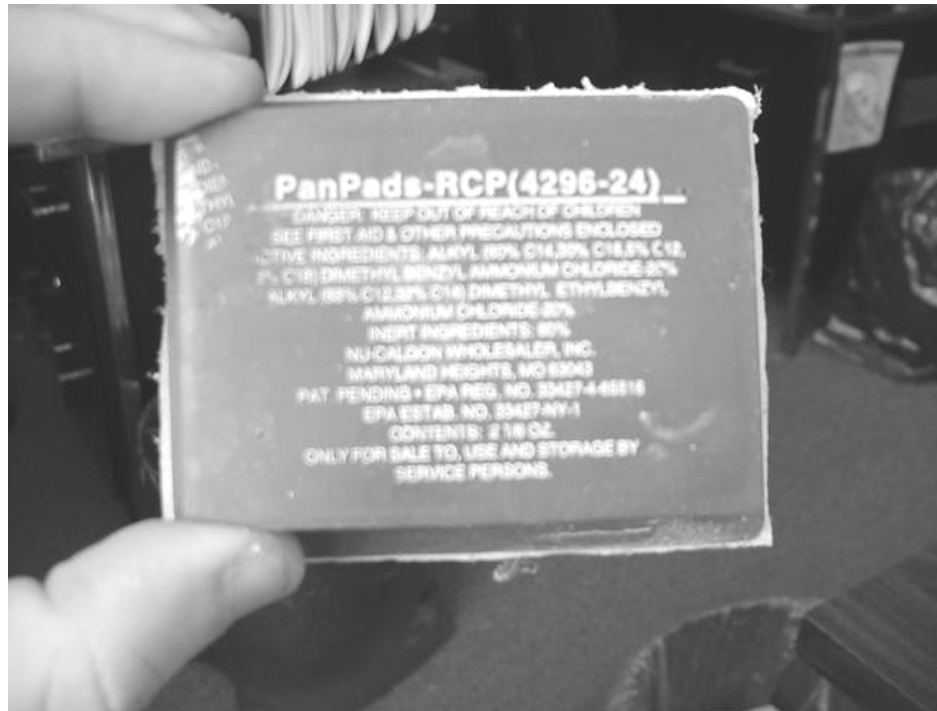
Water Damaged Carpet around FCU Condensation Pump

Picture 16



Mold Growth on Pipe Insulation

Picture 17



Pan Pad® Condensate Treatment Used in FCU Drip Pans

Picture 18



Disconnected Original Exhaust Vent Fan

Picture 18A



Motor For Abandoned Exhaust Fan

Picture 19



Restroom Vent That Terminates In the Attic

Picture 20



Fireplace in City Clerk's Office

Picture 21



Open Container of Rat Poison in Public Health Nurse's Office

TABLE 1

Indoor Air Test Results – Brockton City Hall, Brockton, MA – May 1, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	427	68	21					Weather conditions: sunny/breezy
Mailroom								No condensation pump/drain, floor outlet
Board of Health Office (BOH)-Mary Jane's side	812	76	30	3	Yes	Yes		Water cooler on carpet, sink-holes in floor
BOH-Joe's side	793	77	27	2	Yes	Yes		Window open, computers, photocopier
BOH-Clerk's Office	681	77	28	4	Yes			Flowers, plants, computers
Vault	596	76	26	0	No			Old maps
Public Works- Water & Sewer	578	76	25	2				Lamination machine, photocopier
Public Works-Main Office	744	77	28	5	No			Personal fans-1 on, computers, carpet
Czaja Office	642	76	27	0	Yes			Plant-standing water, door open, water cooler on carpet in hallway
Commissioner's Office	711	76	27	0	Yes			Door open

* ppm = parts per million parts of air
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 2

Indoor Air Test Results – Brockton City Hall, Brockton, MA – May 1, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Commissioner's Secretary	708	76	27	1	No			Door open
Assessor's Map Room	514	77	24	5	Yes	No	No	
Assessor's Main Lobby	534	77	25	1	No	No	No	
Assessor's Private Office	599	77	27	1	Yes	No	No	Fan coil unit blocked by file cabinet-off, 1 water-damaged CT
26 Outer	585	77	26	2	Yes	No	No	Fan coil unit blocked by file cabinet-off, exposed heat pipe (220°F), temperature complaints-cold
2 nd Floor Hallway	553	77	26	0	No	No	No	
Community Relations	817	77	32	2	Yes	No	No	Fan coil unit-off
Registrar's Private Office	613	75	27	6	Yes	No	Yes	Exhaust-off, fan coil unit-off, window open, 5 water-damaged CT
City Clerk's Office	626	76	33	3	Yes	No	Yes	Exhaust-off, fan coil unit-off, fireplace-air filter

* ppm = parts per million parts of air
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 3

Indoor Air Test Results – Brockton City Hall, Brockton, MA – May 1, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Assessor's Storage	467	72	21	0	Yes			Window open, wet carpet
Tax Collector (TC) – Lillian/Cheryl	790	74	28	1	Yes			Door open
TC – Jean	821	76	33	0	Yes			
TC-Martelli	702	76	33	0	Yes			
TC-Betty/Linda	963	77	32	4	Yes			Water cooler on carpet
TC – Front Window Office	866	78	30	6	Yes			Door open
Deputy Tax Collector's Office	641	76	24	1	Yes			2 water-damaged CT, personal fan
Treasurer's Office	693	74	28	1	Yes			Door open, water bottles on carpet, sink
Mayor's Office- Reception Area	621	75	30	2	No			Ceiling fans, water cooler on carpet, plants
Communications Area	856	77	33	1	No			
Chief of Staff's Office	793	75	27	3	Yes			Window and door open, plant

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CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 4

Indoor Air Test Results – Brockton City Hall, Brockton, MA – May 1, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Mayor's Office	563	75	29	0	Yes			Door open, closet, IAQ complaints
Registry of Voters Office	847	78	27	4	Yes			HEPA air filter, 9 water-damaged CT, plants, printers
Clerk's Office	684	77	23	9	Yes			Window open, floor fan-on, photocopiers
Clerks – Records	641	77	25	0	Yes			Paint over water-damaged CT
Assessors Office Clerks	535	75	23	6	Yes			Window open, 10 plants, ceiling fan, humidifier, beanie babies®
Assessors Office	616	75	24	4	Yes			3 plants, ionizer-filters, door open
Assessors Kitchen	594	77	24	0	No			Plant, water-cooler on carpet
Conference Room	639	78	24	3	Yes			Window open, plants
Restroom							Yes	Exhaust activated by light switch
Copy closet								Photocopier, dry erase board, moldy CT
Borges Office	637	78	26	0	Yes			Window and door open

* ppm = parts per million parts of air
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
 600 - 800 ppm = acceptable
 > 800 ppm = indicative of ventilation problems
 Temperature - 70 - 78 °F
 Relative Humidity - 40 - 60%

TABLE 5

Indoor Air Test Results – Brockton City Hall, Brockton, MA – May 1, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Water Office	694	79	26	1	Yes			Door open, personal fan
Rotundra-2 nd floor	551	77	25	0	No			
Payroll/Auditing- Main Office	636	78	25	4	Yes			Holes in CT, personal fans-on, water cooler on carpet, ceiling fan- on, photocopier
GAR Room	546	77	27	0	Yes			Door open
Toilet Room	539	77	35	0	No		Yes	Must activate exhaust
Treasurer's Office	559	75	23	4	Yes			Photocopier, water cooler on carpet, window open

* ppm = parts per million parts of air
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
 600 - 800 ppm = acceptable
 > 800 ppm = indicative of ventilation problems
 Temperature - 70 - 78 °F
 Relative Humidity - 40 - 60%